Title

Reasoned and implicit processes in heavy episodic drinking: An integrated dual-process model.

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Abstract

Objectives: Heavy episodic drinking (HED) in University students contributes to injury risk, impaired educational outcomes, and economic costs. Identification of the determinants of this risky behavior may provide formative evidence on which to base interventions to curb HED in this population. Drawing from social cognition theories and dual-process models, this study tested effects of habits, past behavior, and implicit alcohol identity on HED in a sample of university students. **Design:** A two-wave correlational design was adopted. **Methods:** Students (*N*=204) completed measures of constructs from social cognition theories with respect to HED at an initial time point (T1): attitude, subjective norm, perceived behavioral control, intentions, habit, past behavior, and implicit alcohol identity. Four weeks later (T2), students self-reported their HED behavior and habit. **Results:** Path analyses indicated attitude and subjective norm predicted intentions, and intentions and implicit alcohol identity predicted HED. Inclusion of past behavior and habit revealed direct effects of these on HED. Effects of T1 habit on HED were indirect through T2 habit, and there were indirect effects of past behavior on HED through habit at both time points and the social cognition constructs. Direct effects of intentions and implicit alcohol identity, and indirect effects of attitude and subjective norm, on HED were attenuated by the inclusion of past behavior and habit. **Conclusion:** Results indicate that university students' HED is directly predicted by habit and past behavior, which have largely been interpreted as representing non-conscious, implicit processes, while effects of constructs representing conscious, reasoned processes did not predict HED.

Key words: alcohol; implicit association task; theory of planned behavior; dual process model; university students

Data availability statement: Data files and analysis scripts are available online from the Open Science Framework project for this study: https://osf.io/rj8ud

Introduction

Heavy episodic drinking (HED) is a high-risk pattern of drinking in which individuals consume a high amount of alcohol over a relatively short period of time. Globally, over 1 billion drinkers are heavy episodic drinkers (WHO, 2018). HED among young adults is particularly prevalent in high income countries such as the United States, Canada, and Australia (WHO, 2018), and is especially common among university students. For example, in Australia, around 50% male and 35% female university students consumed alcohol at hazardous levels (Stafford, 2017). HED has been associated with deleterious effects including increased risk of injury and involvement in incidence of interpersonal violence and social disorder, and poor academic outcomes (NHMRC, 2009; WHO, 2018). Definitions of HED vary by country and organization, but according to the WHO (2018) it is defined as consuming more than six ‘standard’ drinks (any alcoholic beverage containing 10g of alcohol) in one session, at least monthly (WHO, 2018). The overrepresentation of university students engaging in HED and the consistently small effects of interventions aimed at curbing student HED (Prosser, Gee, & Jones, 2018) emphasizes the need to identify the determinants and associated mechanisms driving this behavior in this population. Recent research has applied social cognition theories to identify the psychological correlates of risky alcohol consumption behaviors, including HED, and the processes involved (Caudwell, Keech, Hamilton, Mullan, & Hagger, 2019). A leading approach has been to adopt integrated models of social cognition that encompass constructs representing reasoned and implicit processes that lead to behavioral engagement (Strack & Deutsch, 2004). Consistent with this approach, the present study focused on identifying the determinants of HED in a sample of university students based on this integrated approach. The research may assist in identifying the modifiable determinants that may be targeted in behavioral interventions to reduce HED incidence.

We propose a set of key hypotheses relating to constructs that represent reasoned and implicit pathways to action for HED in a sample of university students who were regular social drinkers. Specifically, our hypotheses were derived from an integrated social psychological model drawing from previous research on social cognition theories (Ajzen, 2011) and dual process models (Strack & Deutsch, 2004) applied to health behavior. The proposed model is presented in Figure 1.

In the present model, reasoned processes are represented by the effects of the belief-based constructs and intentions from the theory of planned behavior (Ajzen, 2011). Specifically, attitude, subjective norm, and perceived behavioral control are expected to predict HED mediated by intentions. However, consistent with previous research and theory, HED is characterized as an appetitive behavior that is likely influenced by implicit processes that reflect non-conscious decision making such as affect and situational cues, and affect behavior beyond an individual's awareness (Caudwell et al., 2019). In the present model, we included two measures that reflect these implicit processes: self-reported habit and implicit alcohol identity. Implicit alcohol identity was proposed to reflect non-conscious evaluations of alcohol consumption developed through repeated experiences with alcohol. Self-reported habits reflect the extent to which individuals experience the behavior as enacted beyond their awareness, efficiently and automatically, likely developed through frequent experience with the behavior in the presence of stable contexts and cues (Orbell & Verplanken, 2010). Consistent with the proposal that these constructs represent implicit approaches, we expect both constructs to have direct effects on HED behavior bypassing intentions. Effects of these constructs may also attenuate effects of the social cognition constructs to the extent that they reflect previous decision making and rumination over performing the behavior. In our model, we extended previous research examining habitual effects in social cognition theories (Allom, Mullan, Cowie, & Hamilton, 2016; Hamilton, Kirkpatrick, Rebar, & Hagger, 2017) by

including measures of habit at both the initial time point and at follow-up alongside the measure of behavior. Such effects may demonstrate the extent to which habits are stable for this behavior, and account for past behavior effects over time. Finally, we examined effects of past behavior in the model, conceptualized as previous frequency of participation in HED. Past behavior has been proposed to model numerous non-conscious processes including habits and decisions based on implicit cognition or behavioral 'scripts' (Brown, Hagger, Morrissey, & Hamilton, 2017; Ouellette & Wood, 1998). We therefore expected past behavior to have direct effects on subsequent behavior. Furthermore, to the extent that habit and implicit alcohol identity mediated effects of past behavior on subsequent behavior, we will have evidence as to the types of non-conscious processes modeled by past behavior. We therefore also expect indirect effects of past behavior on subsequent HED over time through self-reported habit and implicit alcohol identity. Finally, we also expected effects of habit and past behavior to be mediated by intention and the social cognition constructs, consistent with the premise that these variables also reflect previous decision-making (Ajzen, 2002b).

Methods

Participants

Participants (N = 204, 68.63% female; mean age = 20.03 years, SD = 2.15) were undergraduate university students. Participants were recruited using a combination of face-to-face and online methods. Face-to-face recruitment involved direct approach by a member of the research team, with the potential participant being given a flyer containing the study URL. Online recruitment included notices sent in broadcast emails to all students at the university, notices posted on Facebook, and a notice posted on the school subject/participant pool. Participants were offered entry into a prize draw or course credit as an incentive for participation. Data were collected across two university semesters. Eligibility criteria included being aged between 18 and 25 years, a drinker of alcohol, an undergraduate student,

and not currently pregnant.

Design and Procedure

The study was conducted between May and November 2016. A two-wave prospective correlational design was used with participants visiting the HaPI laboratory (55%) or completing an online survey (45%) at an initial time point (T1) and a single follow-up conducted remotely by email or telephone (T2). At T1, participants were asked to read a brief information passage and complete a consent form. Next, they were presented with a passage defining the target behavior ("Heavy episodic "binge" drinking is consuming more than six standard drinks on a single occasion") and a pictorial guide providing examples a standard drink for common alcoholic beverages. Participants then completed self-report measures of social cognitive variables (intention, attitude, subjective norm, perceived behavioral control, habit, and past behavior) presented using the Qualtrics™ online survey tool. Participants then completed a measure of implicit alcohol identity using an implicit association test (IAT) administered by the Inquisit™ experimental software. Participants were contacted four weeks to complete follow-up measures of self-reported frequency of HED and self-reported habit. Approval for study procedures was granted from the Griffith University Human Research Ethics Committee. All procedures were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

Measures

Study measures were multi-item self-report measures of social cognitive constructs, habit, and past frequency of HED based on published guidelines and measures used in previous studies (Ajzen, 2002a; Caudwell et al., 2019; Gardner, Abraham, Lally, & de Bruijn, 2012). Participants provided their responses on scales with between five- and seven-point

response options (see Table 1).

Social cognitive constructs. Measures of constructs from the theory of planned behavior were developed according to published guidelines (Ajzen, 2002a). Participants completed measures of intentions (e.g., "I intend to engage in heavy episodic drinking in the next four weeks"), attitude (e.g., "For me to engage in heavy episodic drinking in the next four weeks would be: *bad-good*"), subjective norm (e.g., "Those people who are important to me would want me to engage in heavy episodic drinking in the next four weeks"), and perceived behavioral control (e.g., "I have complete control over whether I engage in heavy episodic drinking in the next four weeks").

Habit. Self-reported habit was measured using the 4-item self-reported behavioral automaticity index (e.g., "Heavy episodic drinking is something I do automatically") (Gardner et al., 2012).

Past behavior. Participants completed a two-item measure of their engagement in the target behavior in the past month (e.g., "How often have you had 6 or more standard drinks, on a single occasion in the last four weeks?").

Demographic variables. Participants self-reported their sex, age in years, and annual household income stratified by seven income levels based on national taxation brackets. A binary income variable was computed for use in analyses with ≥AU$37,001 as the cutoff for lower and middle-to-high household income groups.

Implicit alcohol identity. Implicit alcohol identity was measured using the drinking identity implicit association test (DI-IAT) (Lindgren et al., 2015). Participants sort word stimuli into one of two categories, with response latencies used to calculate a *D*-score for each participant. Positive *D*-scores indicate words related to drinking being more quickly associated with words related to themselves in the sorting process, whereas negative *D*-scores are indicative of drinking words being more quickly associated with words not related to

themselves (see Table 2 for details). *D*-scores were calculated using the improved scoring algorithm for the IAT (Greenwald, Nosek, & Banaji, 2003; Lane, Banaji, Nosek, & Greenwald, 2007). Specifically, the D_1 variant of the *D*-score was used. The scoring procedure involved trials with latency greater than 10,000 ms were deleted, and subjects where greater than 10% of trials were less than 300 ms were excluded. The inclusive *SD*s between blocks 3 and 6, and 4 and 7 were computed. Mean latencies for block 3, 4, 5, and 6 were computed. The mean latency for block 3 was subtracted from the mean latency for block 6, and block 4 was subtracted from block 7. The resultant difference scores were then divided by their associated inclusive standard deviation mentioned above, and these ratios averaged to compute the final *D*-score. Participants were required to correct errors before proceeding, so the optional error penalty was not applied (Lane et al., 2007).

Data Analysis

Manifest measures of study constructs were computed by averaging item scores for each participant for each measure. Our hypothesized models were tested using path analysis with bootstrapped standard errors (Hayes, 2018). We specified two models. An initial model (Model 1) in which reasoned processes were represented by direct effects of the social cognitive constructs on intentions, intentions on follow-up HED behavior, and indirect effects of the social cognitive constructs on behavior through intentions. In addition, implicit alcohol identity was set as a direct predictor of behavior, and an indirect predictor through intentions. These effects are summarized in Figure 1. We also estimated an augmented model (Model 2), which tested effects of self-reported habit and past behavior on relations among constructs in Model 1. The initial model was augmented to include direct effects of habit at the initial time point and at follow-up, and past frequency of HED, on follow-up behavior. Indirect effects of past behavior and habit on behavior through the social cognitive constructs, intentions, and implicit alcohol identity were also estimated. The effects are presented in Figure 2. All model

effects were controlled for sex, age, and income. We computed specific and total indirect effects using a maximum likelihood estimation method with 1000 bootstrap replications. Goodness of fit of the models with the data were evaluated using multiple criteria comparing the proposed model with the baseline model including the goodness-of-fit chi-square (χ^2) which should ideally be non-significant, the comparative fit index (CFI) which should exceed .95, the standardized root mean square residual (SRMR) which should be less than or equal to .08, and the root mean square error of approximation (RMSEA) which should be below .05 with a narrow 90% confidence interval. Models were estimated using the *lavaan* package in R (Rosseel, 2012) with missing data imputed using the full information maximum likelihood (FIML) method. The only missing data were the Time 2 data for participants lost to follow-up. Little's test indicated that this data was missing completely at random. Simulation studies comparing approaches to handing missing data by Enders and Bandalos (Enders & Bandalos, 2001) indicated FIML estimation is superior to deletion methods and response pattern imputation and that FIML provides unbiased estimates when data is missing at random or completely at random. Data files and analysis scripts are available online from the Open Science Framework project for this study: https://osf.io/rj8ud.

Results

Participants

Of the participants that completed the initial survey (N = 204), 121 (64.46% female; mean age = 19.87 years, SD = 2.11) provided complete data for analysis after the second wave questionnaire (40.69% attrition rate). Tests for systematic differences in sample demographic characteristics due to attrition revealed no differences in sex distribution (χ^2 = 1.944, p = .163), income distribution (χ^2 = 2.391, p = .122), and age (t (202) = 1.341, p = .181, d = .188) between those who provided complete data at follow-up and those who dropped out or were eliminated due to a high proportion of missing data. Similarly, a

MANOVA found no systematic differences due to attrition for the social cognitive (attitude, subjective norm, perceived behavioral control, intentions), self-reported habit, implicit alcohol identity, and self-reported HED variables (Wilks $\Lambda = 0.976$, F (7, 143) = 0.490, p = .841). We also tested for differences in sample demographic characteristics and study variables across participants tested in the lab (n = 42, 34.71%) and those tested online (n = 79, 65.29%) to provide a basis for pooling data from these groups of participants. We found no differences in sex ($\chi^2 < .001$, p = 1.000) or income ($\chi^2 = 0.029$, p = .965) distribution between participants tested in the lab and those tested online. However, those tested in the lab (M = 20.69, SD = 2.26) were slightly older than those tested in online (M = 19.43, SD = 1.90), t (119) = 3.250, p = .002, d = .591. We also found no differences in the psychological and behavioral measures between participants tested in the lab and tested online (Wilks Λ = 0.924, F (7, 113) = 1.330, p = .242).

Model Tests

Statistically significant parameter estimates for Models 1 and 2 are presented in Figures 1 and 2, respectively. Full results of the path analytic models for each behavior including unstandardized and standardized parameter estimates, confidence intervals, and test statistics for direct, indirect, and total effects are provided in Table 2. We also computed post hoc statistical power using the *WebPower* package in R (Zhang & Yuan, 2018) to ensure that we had sufficient power to detect desired effects. Power was estimated using Satorra and Saris' (1985) formula, with the sample size and degrees of freedom for each models, effect size estimated using the formula: $\chi^2/(n\text{-}1)$, and alpha set at 0.05. Reproduced statistical power was .858 for Model 1 and .678 for Model 2[1].

Model 1. Model 1 tested effects of social cognitive constructs from the theory of planned behavior alongside our measure of implicit alcohol identity on HED (Figure 1).

[1]Analysis scripts and output for the power analysis are available online from the Open Science Framework (OSF) project for this study: https://osf.io/rj8ud

Although two of the incremental fit indices (CFI, SRMR) indicated good fit of the model with these data, the goodness-of-fit chi-square was statistically significant and the RMSEA exceeded recommended cut off values, indicating some misfit (χ^2 (2) = 11.197, p = .004; CFI = .966; SRMR = .027; RMSEA = .150, 90% CI = .073, .241)[2]. Consistent with hypotheses, we found statistically significant effects of attitude, subjective norm, and perceived behavioral control on intentions, and intentions on HED. We also found significant indirect effects of attitude, subjective norm, and perceived behavioral control on HED mediated by intentions. Contrary to our predictions, however, perceived behavioral control did not predict behavior directly. Consistent with our predictions, implicit alcohol identity was a statistically significant predictor of HED, with a small-to-medium sized effect, alongside the comparatively larger effect of intentions (Ajzen, 2011). There was no effect of implicit alcohol identity on intentions. Overall, the model accounted for significant proportions of the variance in intentions (R^2 = .497) and HED (R^2 = .299).

Model 2. In Model 2 introduced effects of self-reported habit at both time points and past behavior as predictors of model constructs (Figure 2). The model fit the data well according to the multiple criteria adopted (χ^2 (9) = 12.459, p = .189; CFI = .994; SRMR = .023, RMSEA = .043, 90% CI = .000, .096)[3]. We found statistically significant direct effects of past behavior on attitude, subjective norm, implicit alcohol identity, intentions, habit at

[2]Evaluation of the modification indices for this model indicated that model fit would be improved by adding direct effects of the attitude and subjective norm constructs on HED. Although these effects may have been tenable from a statistical perspective, they are not consistent with theory. Nevertheless, for completion we re-estimated the model to include these direct effects in an alternative model. Model fit was perfect as it was a saturated model. The model revealed a statistically significant effect of attitude on HED with a medium effect size, but a small non-significant effect of subjective norm on HED. The overall pattern of effects for intention and implicit alcohol identity remained, although the effects for both were smaller, and the effect for implicit alcohol identity fell marginally short of conventional alpha level for statistical significance (p = .073). Results of this supplementary analysis can be found on (OSF) project for this study: https://osf.io/rj8ud

[3]As with Model 1, we estimated an alternative model in which attitude and subjective norm were direct predictors of HED, along with habit at time 1. Results revealed a well-fitting model (χ^2 (2) =8.056, p = .234; CFI = .996; SRMR = .020; RMSEA = .041, 90% CI = .000, .106), with a small effect for attitude on HED which fell marginally short of conventional alpha level for statistical significance (p = .078), and a small non-significant effect for subjective norm. The overall pattern of effects was unchanged from the original model, with habit and past behavior emerging as the only statistically significant predictors of HED. Results of this supplementary analysis can be found on (OSF) project for this study: https://osf.io/rj8ud.

time 1, and HED. We also observed significant direct effects of habit at time 1 on implicit alcohol identity, intentions, subjective norms, and habit at time 2. In addition, we found a significant direct effect of habit at time 2 on HED. Analysis of indirect effects revealed that effects of habit at time 1 on HED were directed through habit at time 2, as predicted. Similarly, there was a significant indirect effect of past behavior on HED through habit at both time points. We also found significant indirect effects of past behavior through both habit and the social cognitive variables resulting in a significant total indirect effect of past behavior on HED. The mediation proportion statistic (P_M) (Ditlevsen, Christensen, Lynch, Damsgaard, & Keiding, 2005) indicated that the indirect effect of past behavior on HED through habit only accounted for a modest proportion of the total effect of past behavior on HED (P_M = .117), suggesting that the substantive proportion of the effect of past behavior on HED was unaccounted for by habit. The social cognition constructs also accounted for a non-trivial, but relatively modest, proportion of the effect of past behavior on HED (P_M = .083). This indirect effect likely represents the extent to which past behavior reflects previous reasoned, deliberation over performing HED in the future. Finally, consistent with previous research applying social cognitive theories to predict health behavior (Brown et al., 2017), including alcohol consumption (Caudwell et al., 2019; Norman & Conner, 2006), introducing past behavior and habit as predictors in the model attenuated model effects. Specifically, direct effect of intentions on HED, and indirect effects of attitude and subjective norm on HED through intentions, were significantly reduced with the inclusion of past behavior and habit. In addition, the effect of implicit alcohol identity on HED was reduced in size so that it was no longer statistically significant. Tests of difference using Schenker and Gentleman's (Schenker & Gentleman, 2001) standard method based on confidence intervals are available online from the Open Science Framework project for this study: https://osf.io/rj8ud.

Discussion

We tested an integrated model based on social cognitive and dual-processing theories to predict social drinkers' engagement in HED. Reasoned processes were represented by effects of the social cognition constructs and intentions from the theory of planned behavior, and implicit processes were represented by effects of implicit alcohol identity measured using an implicit association test. We also included measures of self-reported habit and past behavior, which can encompass information relating to both reasoned and implicit processes. An initial model indicated that drinkers' attitude and subjective norm predicted intentions, and intentions and implicit alcohol identity predicted participation in HED. These findings support the proposal that HED is a function of sets of beliefs that reflect reasoned and implicit processing. Inclusion of past behavior and self-reported habit in the model, revealed direct effects for habit and past behavior on HED. Effects of Time 1 habit on HED were indirect through Time 2 habit, and there were also indirect effects of past behavior on HED through habit at both time points and the social cognitive variables. The direct effect of intentions and implicit alcohol identity, the indirect effects of attitude and subjective norm, on HED were attenuated by the inclusion of habit and past behavior.

Several notable implications for the determinants of HED emerged from this study, which extend previous research and may provide formative evidence on which to base behavioral interventions. First, the finding that implicit alcohol identity predicted behavior unmediated by intentions is consistent with dual-process theories (Strack & Deutsch, 2004) and previous research on alcohol, which suggests that implicit attitudes model non-conscious processes that determine behavior (Caudwell et al., 2019). These implicit beliefs are likely to have been built up over time through regular positive experiences with the behavior (e.g., enjoying drinking alcohol at someone's home, or in a club, or at a bar) which are likely activated or made highly accessible on presentation of relevant contexts (e.g., being in a bar with friends) (Hagger, 2020). This increases the likelihood that individuals holding such

implicit beliefs will participate in drinking behavior with very little cognitive input required when they find themselves in that context. HED for university students is likely a highly rewarding behavior regulated by previously-learned behavioral patterns. However, the fact that intentions also predicted behavior suggests that HED is determined by reasoned decision making. A likely interpretation of these data is that some individuals are more likely to engage in HED as a consequence of an implicit process, while others' decisions are determined by reasoned process.

Attenuation of the effects of the constructs representing reasoned processes that lead to behavior such as intentions, attitude, and subjective norm by past behavior and habit suggests that risky alcohol consumption is strongly influenced by previous experience and habit. The attenuating effects of past behavior and habit on effects of these constructs has been consistently observed in previous research applying social cognitive theories (for a meta-analyses, see Hagger, Chan, Protogerou, & Chatzisarantis, 2016; Hagger, Polet, & Lintunen, 2018). Findings indicate that observed effects of social cognition variables on behavior in previous research are likely inflated in the absence of habits and past behavior, and may give a misleading assessment on the extent to which behaviors, like HED, are predicted by constructs representing reasoned processes. In addition, the effect of implicit alcohol identity was also attenuated to a smaller value indicating that habits and past behavior may largely account for the effects of implicit beliefs. These findings indicated that implicit alcohol identity, like many implicit measures, are likely to reflect representations of the behavior developed though experience. As before, implicit alcohol identity is likely developed over time through consistent experiences of alcohol consumption with similar accompanying self-related evaluations (Abelson, 1981; Hagger, 2019). As a consequence, although implicit identity is a direct determinant of HED, current data indicate that this effect is largely dependent on past experience, an unsurprising finding given that frequency of past behavior

is an important, although not the only, component of habit (Ouellette & Wood, 1998; Wood & Rünger, 2016). These findings, at least, shed light on the potential reason why implicit alcohol identity accounts for variance in HED. Nevertheless, it would be important to establish whether such implicit measures predict behavior in the face of past behavior in novice heavy episodic drinkers, and among those with different, more moderate drinking patterns.

The indirect effect of past behavior through habit on HED suggests past risky drinking behavior is, at least in part, a function of habits. Previous research has suggested that past behavior serves to summarize effects of habits on behavior. For example, studies have demonstrated that past behavior effects are much larger for behaviors that individuals perform regularly in the presence of stable contexts or cues, such as drinking heavily when out with friends at a bar (Ouellette & Wood, 1998). Habits, therefore, would be expected to mediate effects of past behavior on subsequent behavior, an observation found in the current study and in previous research (van Bree et al., 2015). However, it should be noted that only a small proportion of the effect of past behavior on HED is accounted for by habit. It could be that the residual effect of past behavior on HED may reflect unmeasured constructs that affect behavior independent of intentions and other social cognition constructs. Examples of these constructs might be implicitly-held beliefs or individual differences that predispose individuals impulsive behavioral patterns such as trait self-control, impulsivity, and certain personality traits (Allom et al., 2018; Hagger, Gucciardi, Turrell, & Hamilton, 2019).

The present research has numerous strengths including a focus on HED, a common yet risky drinking behavior among young university students, and the adoption of an integrated dual-process theoretical approach and appropriate measures. However, several limitations should be acknowledged. HED behavior was measured using a relatively brief self-report measure which may be subject to recall and social desirability bias. Use of more

comprehensive methods such as the time-line follow-back technique, ecological momentary assessment, or breathalyzing individuals may provide more accurate estimates. One of our measures reflecting implicit determinants of HED was implicit alcohol identity. We selected this measure over, for example, implicit attitudes toward alcohol, because we considered it more closely linked to the act of drinking. However, this contrasts with previous research which has focused on implicit attitudes toward the substance in question (e.g., implicit attitudes toward sugar; Hagger, Trost, Keech, Chan, & Hamilton, 2017). Future research should consider testing the relative effects of IATs tapping implicit attitudes toward alcohol and implicit identities on alcohol consumption. It is also important to note that although effects of past behavior and habit are considered as reflecting non-conscious implicit effects, the fact that we found indirect effects of these constructs on HED indicates that they may model both reasoned and implicit effects. In addition, the assumption that the residual effects of these variables on HED reflect non-conscious processes should also be interpreted with caution as the intention and other social cognition constructs in the current study may not have sufficiently captured all aspects of habit and past behavior attributable to reasoned processed. Further, current findings are based on theory alone as the study design did not permit inferences of directionality or causation. The use of longitudinal designs measuring all variables across several time points and the estimation of a cross-lagged paned model would allow the direction of effects to be empirically determined in future tests. While preliminary analyses revealed no significant differences in demographic or baseline psychological variables between those who completed the follow-up and those who did not, it should be noted that the relatively high attrition rate in the current study is a potential limitation. It is also important to note that constructs that represented reasoned and implicit processes were confined to those based on theory (Ajzen, 2011; Strack & Deutsch, 2004) and prior research (Caudwell et al., 2019; Hagger et al., 2017), which may not fully account for the non-

conscious processes that relate to HED. In addition, measures such as the self-report habit index are meta-cognitive measures, which reflect implicit, non-conscious processes rather than tap them directly (cf., Hagger, Rebar, Mullan, Lipp, & Chatzisarantis, 2015; Sniehotta & Presseau, 2012). Investigation of other constructs that may account for, or represent, non-conscious processes in HED such as trait self-control (Hagger, Hankonen, et al., 2019), emotional processes (Conner, McEachan, Taylor, O'Hara, & Lawton, 2015), and individual difference and personality factors (Cyders, Flory, Rainer, & Smith, 2009; Vo & Bogg, 2015) should be considered in future research. Finally, statistical power for our final model including past behavior and habit fell marginally short of typically recommended criterion for adequate power to detect effects. This highlights the imperative for future replications of the current model in larger samples.

Conclusion

Drawing from theories of social cognition and dual-process models, the present study tested key hypotheses for effects of constructs that represent reasoned and implicit pathways to HED in a sample of Australian university students who drink alcohol. Current results indicate that university students' HED is predicted by past behavior and habit. Direct effects of habit and past behavior unmediated by intentions have often been interpreted as representing effects of non-conscious processes on behavior (e.g., Hagger et al., 2018; Ouellette & Wood, 1998). However, it is important to note that measures of intentions and social cognition constructs may not be sufficient in capturing all the information encompassed by habit and past behavior attributable to reasoned processes. Furthermore, direct effects of these variables on behavior may also represent effects of unmeasured constructs that reflect reasoned processes. So solely attributing effects of habit and past behavior on HED to non-conscious processes should be interpreted with caution. Current findings should be viewed as preliminary and require further replication. However, they may

signpost possible avenues for the development of behavior change interventions. For example, interventionists seeking to reduce rates of HED in students may consider strategies that assist in minimizing exposure to contexts or cues that activate implicit alcohol identities such as minimizing availability and creating social events that do not revolve around alcohol consumption, and strategies to provide students with self-regulatory skills such as planning alternative courses of action when in tempting situations (e.g., Duckworth, Gendler, & Gross, 2016; Hagger, 2019; Hollands, Marteau, & Fletcher, 2016). Further research is needed to identify factors that further account for the pervasive effects of past behavior on HED.

Conflicts of Interest

The authors declare that they have no conflict of interest.

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Figure 1. Standardized parameter estimates and probability statistics for path analysis of integrated dual-process model excluding habit and past behavior. T2 = Measure taken at time point 2, 4 weeks after initial survey. *** $p < .001$ ** $p < .01$ * $p < .05$

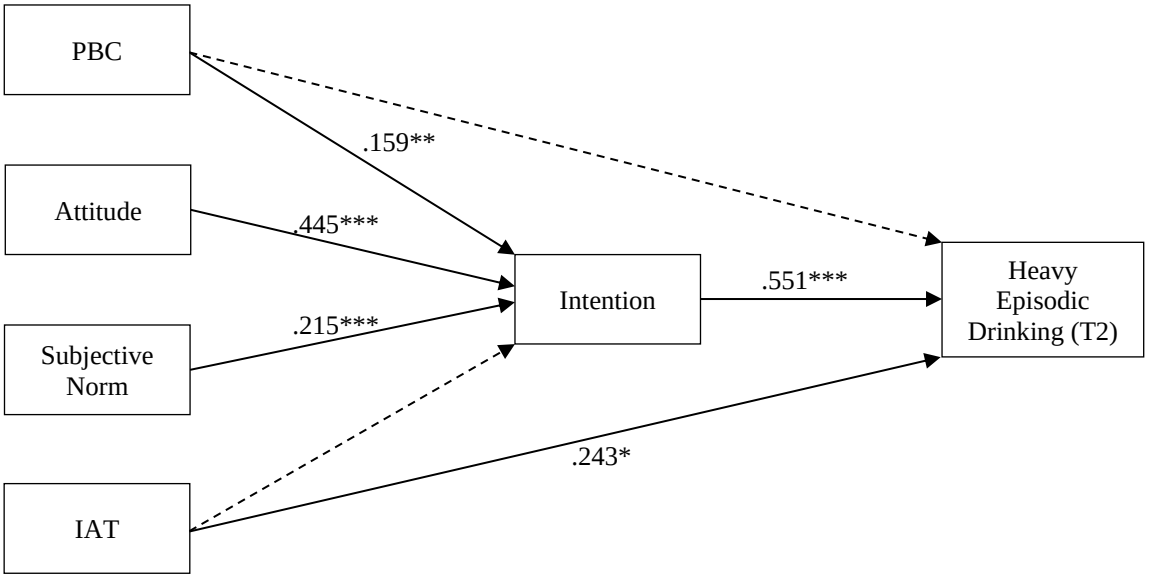

Figure 2. Standardized parameter estimates and probability statistics for path analysis of integrated dual-process model including habit and past behavior. T2 = Measure taken at time point 2, 4 weeks after the initial survey. *** $p < .001$ ** $p < .01$ * $p < .05$

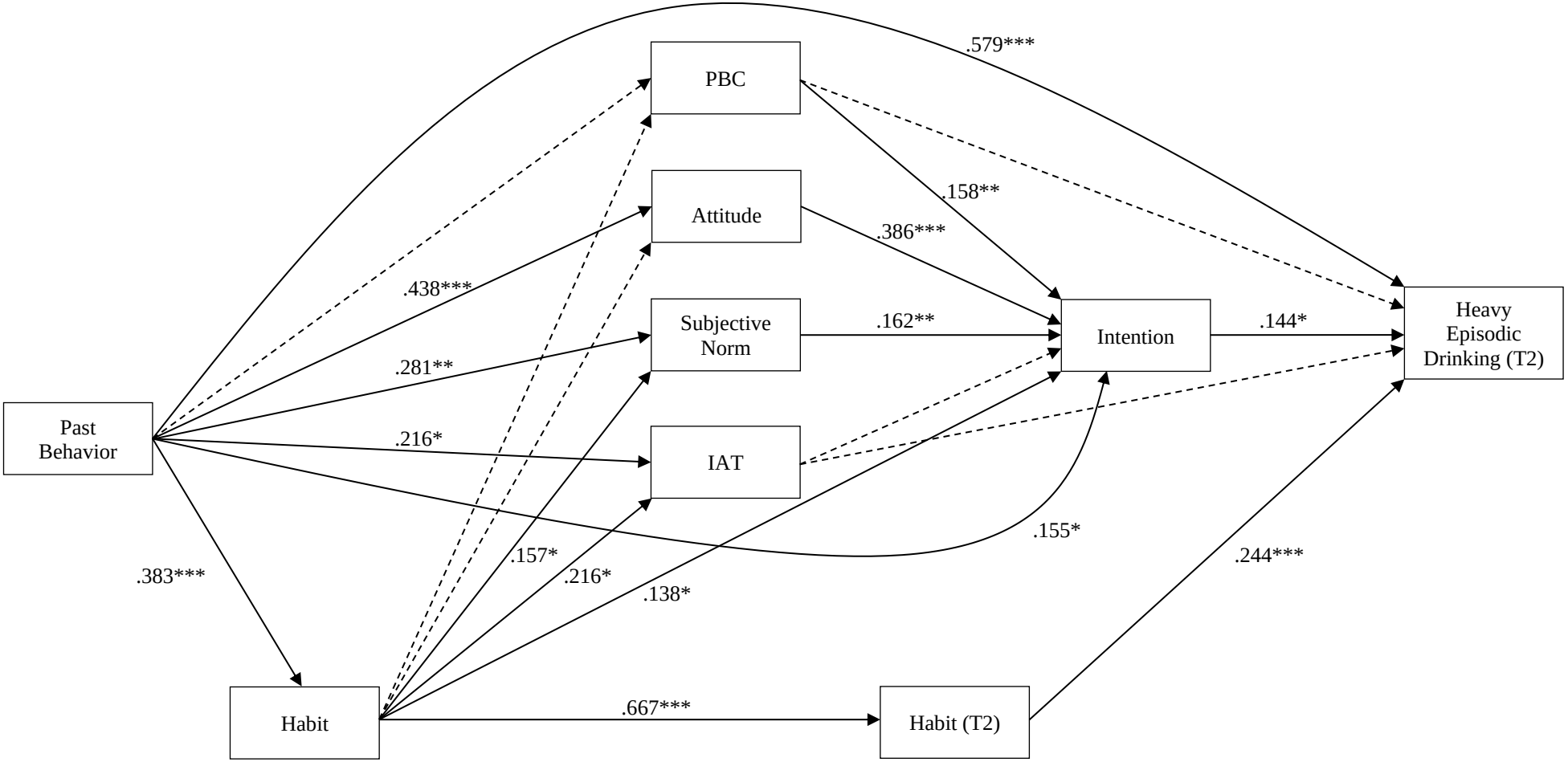

Table 1

Items and Response Scales for Social Cognitive Constructs, Habit, and Behavior Measures for Each Behavior

Construct	ω	Items	Scale
Intention	.98	I am willing to engage in heavy episodic drinking in the next four weeks	1 = strongly disagree, 7 = strongly agree
		I intend to engage in heavy episodic drinking in the next four weeks	
		I expect to engage in heavy episodic drinking in the next four weeks	
		It is likely that I will engage in heavy episodic drinking in the next four weeks	
Attitude	.94	For me engaging in heavy episodic drinking in the next four weeks would be…	1 = bad, 7 = good
			1 = unwise, 7 = wise
			1 = unpleasant, 7 = pleasant
			1 = awful, 7 = nice
Subjective Norm	.94	Those people who are important to me would want me to engage in heavy episodic drinking in the next four weeks	1 = strongly disagree, 7 = strongly agree
		Other university students I know engage in heavy episodic drinking in the next four weeks	
		My friends/mates engage in heavy episodic drinking in the next four weeks	
		Most people who are important to me would approve of me engaging in heavy episodic drinking in the next four weeks	
		Other university students I know think that engaging in heavy episodic drinking in the next four weeks is a good thing to do	
		My friends/mates think that engaging in heavy episodic drinking in the next four weeks is a good thing to do	
		Most people who are important to me think I should engage in heavy episodic drinking in the next four weeks	
		Other university students I know encourage me to engage in heavy episodic drinking in the next four weeks	
		My friends/mates encourage me to engage in heavy episodic drinking in the next four weeks	
Perceived Behavioral Control	.90	I have complete control over whether I engage in heavy episodic drinking in the next four weeks	1 = strongly disagree, 7 = strongly agree
		It is up to me whether I engage in heavy episodic drinking in the next four weeks	
		If I wanted to it would be easy for me to engage in heavy episodic drinking in the next four weeks	
		I am confident that I could engage in heavy episodic drinking in the next four weeks	

Habit	T1 = .90; T2 = .94	Heavy episodic drinking is something I do automatically Heavy episodic drinking is something I do without having to consciously remember Heavy episodic drinking is something I do without thinking Heavy episodic drinking is something I start doing before I realise I am doing it	1 = strongly disagree, 7 = strongly agree
Past behavior	.69[a]	How often have you had 6 or more standard drinks, on a single occasion in the last four weeks? In the last four weeks, how often did you have 6 or more standard drinks on one occasion?	1 = never, 5 = daily
Heavy episodic drinking	.79[a]	How often have you had 6 or more standard drinks, on a single occasion in the last four weeks? In the last four weeks, how often did you have 6 or more standard drinks on one occasion?	1 = never, 5 = daily

Note. [a]Coefficient is inter-item correlation (*r*) as scale comprises only two items. ω = Omega reliability coefficient (Revelle & Zinbarg, 2008)

Table 2

Parameter Estimates and Variability Statistics for the Path Analyses of Hypothesized Model for Heavy Episodic Drinking

Effect	Model Excluding Habit and Past Behavior						Model Including Habit and Past Behavior					
	B	SE	95%CI		β	*p*	B	SE	95%CI		β	*p*
			LB	UB					LB	UB		
Direct effects												
Attitude→Intention	0.562	.088	0.387	0.729	.445	<.001	0.488	.079	0.328	0.644	.386	<.001
SN→Intention	0.314	.081	0.152	0.474	.215	<.001	0.236	.078	0.082	0.399	.162	.003
PBC→Intention	0.299	.110	0.066	0.500	.159	.006	0.298	.115	0.061	0.502	.158	.009
IAT→Intention	0.487	.263	-0.008	1.000	.128	.064	0.271	.260	-0.227	0.770	.071	.297
Habit (T1)→Intention	–	–	–	–	–	–	0.185	.077	0.022	0.338	.138	.016
Intention→HED	0.167	.032	0.101	0.227	.448	<.001	0.053	.025	0.006	0.106	.144	.033
PBC→HED	-0.037	.075	-0.171	0.118	-.053	.625	-0.007	.041	-0.086	0.077	-.010	.873
IAT→HED	0.302	.138	0.021	0.573	.212	.028	0.102	.099	-0.088	0.291	.073	.305
Habit (T2)→HED	–	–	–	–	–	–	0.119	.032	0.053	0.180	.244	<.001
PB→Attitude	–	–	–	–	–	–	0.901	.139	0.656	1.182	.438	<.001
PB→SN	–	–	–	–	–	–	0.500	.127	0.226	0.740	.281	<.001
PB→PBC	–	–	–	–	–	–	0.221	.132	-0.055	0.471	.160	.093
PB→Intention	–	–	–	–	–	–	0.403	.185	0.040	0.771	.155	.029
PB→HED	–	–	–	–	–	–	0.548	.083	0.373	0.711	.579	<.001
PB→IAT	–	–	–	–	–	–	0.147	.060	0.032	0.267	.216	.014
PB→Habit (T1)	–	–	–	–	–	–	0.742	.132	0.486	1.010	.383	<.001
Habit (T1)→Attitude	–	–	–	–	–	–	0.072	.076	-0.071	0.220	.068	.341
Habit (T1)→SN	–	–	–	–	–	–	0.144	.059	0.032	0.262	.157	.015
Habit (T1)→PBC	–	–	–	–	–	–	-0.013	.044	-0.098	0.076	-.018	.770
Habit (T1)→IAT	–	–	–	–	–	–	0.076	.035	0.010	0.147	.216	.030
Habit (T1)→Habit (T1)	–	–	–	–	–	–	0.669	.073	0.524	0.804	.667	<.001
Indirect effects												
Attitude→Intention→HED	0.094	.026	0.049	0.147	.199	<.001	0.026	.014	0.003	0.057	.056	.060
SN→Intention→HED	0.053	.017	0.021	0.090	.096	.002	0.012	.007	0.001	0.029	.023	.070
PBC→Intention→HED	0.050	.021	0.010	0.094	.071	.016	0.016	.010	0.001	0.037	.023	.106
IAT→Intention →HED	0.082	.048	-0.001	0.188	.057	.087	0.014	.017	-0.012	0.056	.010	.400

PB→Attitude→Intention→HED	–	–	–	–	–	–	0.023	.013	0.003	0.056	.024	.078
PB→SN→Intention→HED	–	–	–	–	–	–	0.006	.004	0.000	0.016	.007	.122
PB→PBC→Intention→HED	–	–	–	–	–	–	0.003	.003	-0.001	0.010	.004	.217
PB→Intention→HED	–	–	–	–	–	–	0.021	.015	0.000	0.057	.022	.156
PB→PBC→HED	–	–	–	–	–	–	-0.001	.011	-0.022	0.023	-.002	.891
PB→Habit (T1)→Intention→HED	–	–	–	–	–	–	0.007	.005	0.000	0.018	.008	.137
PB→IAT→Intention→HED	–	–	–	–	–	–	0.002	.003	-0.002	0.009	.002	.448
PB→Habit (T1)→Habit (T2)→HED	–	–	–	–	–	–	0.059	.021	0.021	0.105	.062	.006
PB→IAT→HED	–	–	–	–	–	–	0.015	.017	-0.012	0.057	.016	.392
PB→Habit (T1)→IAT→HED	–	–	–	–	–	–	0.006	.007	-0.006	0.021	.006	.392
PB→Habit	–	–	–	–	–	–	0.001	.002	-0.001	0.006	.001	.437
(T1)→Attitude→Intention→HED												
PB→Habit (T1)→SN→Intention→HED	–	–	–	–	–	–	0.001	.001	0.000	0.003	.001	.142
PB→Habit (T1)→PBC→Intention→HED	–	–	–	–	–	–	0.000	.001	-0.001	0.001	.000	.782
PB→Habit (T1)→Intention→HED	–	–	–	–	–	–	0.007	.005	0.000	0.018	.008	.137
PB→Habit (T1)→IAT→Intention→HED	–	–	–	–	–	–	0.001	.001	-0.001	0.004	.001	.454
Habit (T1)→Attitude→Intention→HED	–	–	–	–	–	–	0.002	.003	-0.002	0.008	.004	.461
Habit (T1)→SN→Intention→HED	–	–	–	–	–	–	0.002	.001	0.000	0.005	.004	.164
Habit (T1)→PBC→Intention→HED	–	–	–	–	–	–	0.000	.001	-0.002	0.002	.000	.790
Habit (T1)→Intention→HED	–	–	–	–	–	–	0.010	.007	0.000	0.027	.020	.163
Habit (T1)→PBC→HED	–	–	–	–	–	–	0.000	.002	-0.004	0.003	.000	.963
Habit (T1)→Habit(T2)→HED	–	–	–	–	–	–	0.079	.024	0.033	0.130	.163	.001
Habit (T1) →IAT→Intention→HED	–	–	–	–	–	–	0.001	.002	-0.001	0.005	.002	.478
Habit (T1)→IAT→HED	–	–	–	–	–	–	0.008	.009	-0.008	0.026	.016	.367
Total indirect effects												
PB→HED	–	–	–	–	–	–	0.152	.038	0.089	0.235	.161	<.001
PB→HED (through Habit only)	–	–	–	–	–	–	0.082	.024	0.041	0.131	.087	.001
Habit (T1)→HED	–	–	–	–	–	–	0.102	.025	0.051	0.153	.208	<.001
Total effects												
PB→HED	–	–	–	–	–	–	0.701	.069	0.570	0.837	.739	<.001
Correlations												
Attitude↔SN	0.879	.132	0.596	1.135	.465	<.001	0.567	.103	0.362	0.762	.364	<.001

Attitude↔PBC	0.387	.107	0.160	0.594	.265	<.001	0.286	.081	0.121	0.439	.224	<.001
Attitude↔IAT	0.231	.059	0.111	0.341	.320	<.001	0.113	.050	0.016	0.215	.190	.023
SN↔PBC	0.136	.098	-0.060	0.317	.108	.167	0.074	.094	-0.104	0.251	.064	.432
SN↔IAT	0.072	.051	-0.031	0.168	.116	.157	-0.019	.043	-0.105	0.066	-.035	.660
PBC↔IAT	0.062	.043	-0.026	0.152	.130	.148	0.042	.038	-0.037	0.115	.094	.268

Note. B = Unstandardized parameter estimate; 95% CI = 95% confidence intervals of unstandardized parameter estimate using bootstrapped standard errors (replications, $n = 1000$); LB = Lower bound of 95% CI; UB = Upper bound of 95% CI; β = Standardized parameter estimate; p = Probability value of unstandardized parameter estimate; SN = Subjective norm; PBC = Perceived behavioral control; IAT = Implicit alcohol identity measured using the implicit association test; HED = Heavy episodic drinking occasions reported at T2; PB = Past behavior; Habit (T1) = Measure of self-reported habit taken at time point 1, the first administration of the survey; Habit (T2) = Measure of self-reported habit taken at time point 2 (T2), 5 weeks after initial survey.

Table 3

Composition of the drinking identity implicit association test (DI-IAT)

Block	Number of trials	Left-key response	Right-key response	Stimuli words
Block 1: Target compatible practice	20	Me	Not me	me, my, mine, self, they, them, theirs, other
Block 2: Attribute practice	20	Drinker	Non-drinker	drinker, partier, drunk, drink, non-drinker, abstainer, sober, abstain
Block 3: Compatible test 1	20	Me Drinker	Not me Non-drinker	me, my, mine, self, they, them, theirs, other, drinker, partier, drunk, drink, non-drinker, abstainer, sober, abstain
Block 4: Compatible test 2	20	Me Drinker	Not me Non-drinker	me, my, mine, self, they, them, theirs, other, drinker, partier, drunk, drink, non-drinker, abstainer, sober, abstain
Block 5: Target incompatible practice	20	Not me	Me	me, my, mine, self, they, them, theirs, other
Block 6: Incompatible test 1	20	Not me Drinker	Me Non-drinker	me, my, mine, self, they, them, theirs, other, drinker, partier, drunk, drink, non-drinker, abstainer, sober, abstain
Block 7: Incompatible test 2	20	Not me Drinker	Me Non-drinker	me, my, mine, self, they, them, theirs, other, drinker, partier, drunk, drink, non-drinker, abstainer, sober, abstain

Note. In completing the DI-IAT, participants sort randomly presented stimuli words into the category on the left (using the ‘E’ key) or the right (using the ‘I’ key). The DI-IAT contains seven blocks which differ based on the presentation of target me or not me) and attribute (drinker or nondrinker) categories, the range of stimuli words, and whether they are a practice or test block. Internal consistency of the IAT was calculated by correlating the mean difference between blocks 6 and 3 with the mean difference between blocks 7 and 4, $r = .61$.